Quasiturbine Rotor Development Optimization

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To My Family with Love

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All praise for Allah S.W.T, blessings to Prophet Muhammad S.A.W along with his family and friends. Thanks to Allah because gave this permission to me prepared and accomplished this master project in title ‘Quasiturbine Rotor Development Optimization” in its time.

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ABSTRACT

The Quasiturbine compressor is still in developing level and its have more advantages if compare with wankel and reciprocating compressors. Quasiturbine was separated in two main important components which they are housing and rotor .Quasiturbine rotor contains a number of parts such as blades, seal, support plate and mechanism .This research focus on modeling and simulation for Quasiturbine seal to improve it and reduce the wear by using motion analysis tool and simulation tool box in Solidworks 2014 software .This study has simulated the existing design and proposed design of seal with use Aluminum (1060 alloy) as a material of seal for both cases . In addition it has been simulated three different materials for the proposed design of seal (Aluminum, ductile iron , steel) .The proposed design of seal was selected as better design than the existing one when compared the distribution of von Mises stress and the percentage of deformation for both cases . According to the results of the three mateials that tested by simulation for the proposed design , ductile iron is the most suitable materials from the three tested materials for Quasiturbine seal .

CONTENTS

Chapter 1

Introduction

1.1 Introduction

The Quasiturbine concept resulted from research that began with an evaluation of all engine concepts, looking at the various advantages, disadvantages and opportunities for improvement of each. The Quasiturbine Engine was invented by the Saint-Hilaire team headed by Dr. Gilles Saint-Hilaire and was first patented in 1996.During this exploratory process, the Saint-Hilaire team came to realize that a unique engine solution would be one that made improvements to the standard Wankel, or rotary engine.The Quasiturbine is at the crossroad of the 3 modern engines: Inspired by the turbine, it perfects the piston, and improves upon the Wankel. The Quasiturbine is universal in relation to energy sources: Pneumatic, Steam, Hydraulic, Combustion, Hydrogen, Detonation, Stirling and Rotary Expander (compressor/pump).

The Quasiturbinedoes not have crankshaft, and is a rotary engine having 4 faces articulated rotor with a free and accessible center, rotating without vibration nor dead time, and producing a strong torque at low RPM under a variety of modes and fuels. The Quasiturbine can also be used as air motor, steam engine,Stirling engine, compressor and pump. The Quasiturbine is also an optimization theory for a compact and efficient engine concept.

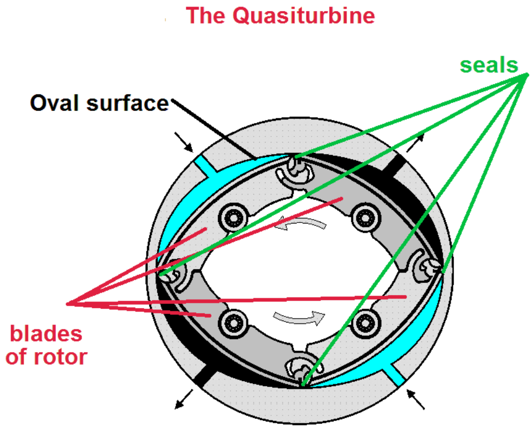

Figure 1.1 Quasiturbine pump/compressor (Hilaire,G.S.,2004)

In the pump mode, the Quasiturbine has 2 intakes and 2 exits related to 2 quasi-distinct circuits. Each circuit can in principle be used in pneumatic or hydraulic mode or vacuum or pressure pump, for compressible or non-compressible fluids. The Quasiturbine is a positive displacement pump, and not an aero- or hydro dynamic one. The Quasiturbine can be driven externally by its central shaft . However, the 2 quasi-independents circuits can in certain applications be used one in pneumatic or hydraulic mode, the other in pump mode. Since the 2 circuits share the moving pivoting blade rotor surface, this mode is mainly reserved to applications where the fluids contamination between the 2 circuits is no problem, or for uses as vacuum pump. In this mixed mode, the Quasiturbine is at the same time the turbo-engine and the pump and has no shaft in the center, the engine circuit being pressurized at its intake port and the exhaust exit being 90 degrees away. The other pumping cycle intakes by the following port and expels at exit 90 degrees further away. In applications like rocket fuel Quasiturbine turbo-pump, the engine cycle can be pressurized by a gas, while the pump cycle handling fuel, the contaminated engine mode exit being injected into the post-combustion. Notice that the flow rate is controlled by the RPM, but the fuel exit pressure is controlled by the gas pressure at the engine circuit intake, a very interesting characteristic in the case of rockets. For all the previous reasons, the Quasiturbine pump and turbo-pump is a breakthrough and open the door to new optimization of present and future devices.

1.2 Problem Statement

Various types of air compressors have been established but the Quasiturbine compressor or pump is still under development and research to enhance the efficiency and solve the issues of the Quasiturbine. The Quasiturbine has many advantages such as higher torque at lower rpm , small size ,light weight, high flow rate and mechanical simplicity but at the same has some issues that need attention such as shortage of stroke duration in engine application , limited speed and short life of seals due to wear that happening by friction between the seals and oval surface of Quasiturbine housing.

This project will progress according to the problem statement below.

i- To design and optimise the Quasiturbine rotor and seal in order to increase the efficiency for these type of compressors.

ii- Analysis and select the optimum materials suitable for the Quasiturbine operations to decrease the concentrating stress and to reduce the wear of seal of Quasiturbine rotor.

The design specifications of seal rotor and housing of the Quasiturbine have not been published in Journals or patents and there is a lack of simulations for these kind of operations .Therefore this work will focus on simulation of the Quasiturbine seal to optimize the previous design of QT seal that done by others .

1.3 Objectives

i- To design a proposed model of rotor seal for a portable Quasiturbine compressor.

ii- To simulate the existing and the proposed model of rotor seal of Quasiturbine compressor by using Solidworks software.

iii- To develop the optimized rotor and seal design of the Quasiturbine compressor.

1.4 Scope of study

i- Selection of a suitable material to decrease the wear on seal and on the oval surface.

ii- Simulate Models from the previous Quasiturbine design that was done and the proposed design of Quasiturbine seal in order to compare the performance of each by using motion analysis and simulation tool box in Solidworks software .

iii- Using simulation assumption (internal pressure of QT compressor 2 bar , spring force of seal 20 N , rotational speed of QT rotor 500 rpm)

iv- Compare the results of von Mises stress, deformation and strain for both existing and proposed models to optimize and improve the efficiency of Quasiturbine seal .

1.5 Expected outcomes

The expected results of this research are:

i- Selection of the most suitable material to decrease the friction between the seals and the oval surface that will reduce the wear of seals.

ii- Von Mises stress, deformation and strain for both the existing and developed rotor of Quasiturbine efficiency can be compared to show how Quasiturbine seal design can be developed further.

CHAPTER 2

LITERATURE REVIEW

2.1 Definition of Quasiturbine

The Quasiturbine is a proposed pistonless rotary engine using a rhomboidal rotor whose sides are hinged at the vertices. The volume enclosed between the sides of the rotor and the rotor casing provide compression and expansion in a fashion similar to the more familiar Wankel engine, but the hinging at the edges allows the volume ratio to increase. Patents for the Quasiturbine are held by Saint-Hilaire. The Quasiturbine has been proposed as a possible pump design, and a possible stirling engine. It has been demonstrated as a pneumatic engine using stored compressed air, and as a steam engine. What is emphasized in this project is the design a pump (Curodeau,2012)

The Quasiturbine crankshaft rotary engine having a 4 faces articulated rotor with a free and accessible center, rotating without vibration or dead time, and producing a strong torque at low RPM under a variety of modes and fuels. The Quasiturbine design can also be used as an air motor, steam engine, gas compressor or pump .In the pump mode, a Quasiturbine driven by an external motor has 2 intakes and 2 exits related to 2 quasi-distinct circuits. Possible absence of check valve is of considerable interest in many applications because each Quasiturbine has 2 quasi-independent circuits, one can be used in pneumatic, steam or hydraulic motor mode, while the other is used as vacuum or pressure pump.(Saint-Hilaire , 2004)

2.2 Principle of Quasiturbine

Like Wankel engines, the Quasiturbine engine is based on a rotor and housing design. But instead of three blades of rotor, the Quasiturbine rotor has four elements chained together, with combustion chambers located between each element and the walls of the housing. The four-sided rotor is what sets the Quasiturbine apart from the Wankel. There are actually two different ways to configure this design — one with carriages and one without carriages. As we'll see a carriage, in this case, is just a simple machine piece.

First, let's look at the components of simpler Quasiturbine model — the version without carriages. The simpler Quasiturbine model looks very much like a traditional rotary engine: A rotor turns inside a nearly oval-shaped housing. Notice, however, that the Quasiturbine rotor has four elements instead of three. The sides of the rotor seal against the sides of the housing, and the corners of the rotor seal against the inner periphery, dividing it into four chambers.(Saint-Hilaire ,2007)

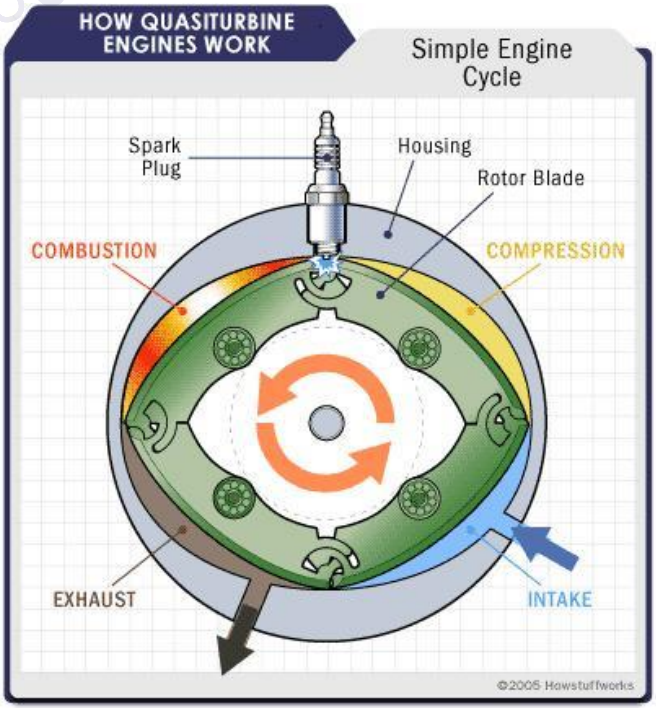

Figure 2.1 Quasiturbine without carriage

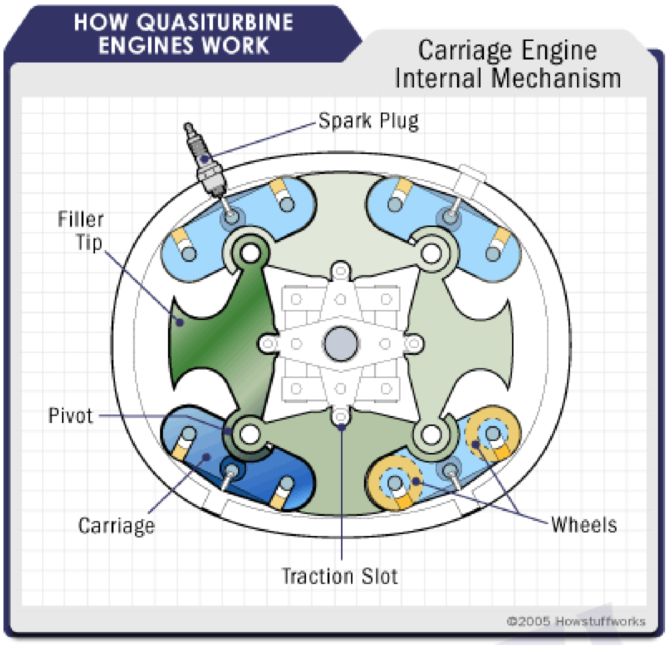

Figure 2.2 Quasiturbine with carriage

In a piston engine, one complete four-stroke cycle produces two complete revolutions of the crankshaft. That means the power output of a piston engine is half a power stroke per one piston revolution. A Quasiturbine engine, on the other hand, doesn't need pistons. Instead, the four strokes of a typical piston engine are arranged sequentially around the oval housing. There's no need for the crankshaft to perform the rotary conversion.

It's very easy to see the four cycles of internal combustion:

• Intake, which draws in a mixture of fuel and air

• Compression, which squeezes the fuel-air mixture into a smaller volume

• Combustion, which uses a spark from a spark plug to ignite the fuel

• Exhaust, which expels waste gases (the byproducts of combustion) from the engine compartment Quasiturbine engines with carriages work on the same basic idea as this simple design, with added design modifications that allow for photo-detonation. Photo-detonation is a superior combustion mode that requires more compression and greater sturdiness than piston or rotary engines can provide.

In the pump mode, the Quasiturbine driven by an external motor has 2 intakes and 2 exits related to 2 quasi-distinct circuits. Possible absence of check valve is of considerable interest in many applications because each Quasiturbine has 2 quasi-independent circuits, one can be used in pneumatic, steam or hydraulic motor mode, while the other is used as vacuum or pressure pump .(Saint-Hilaire ,2007)

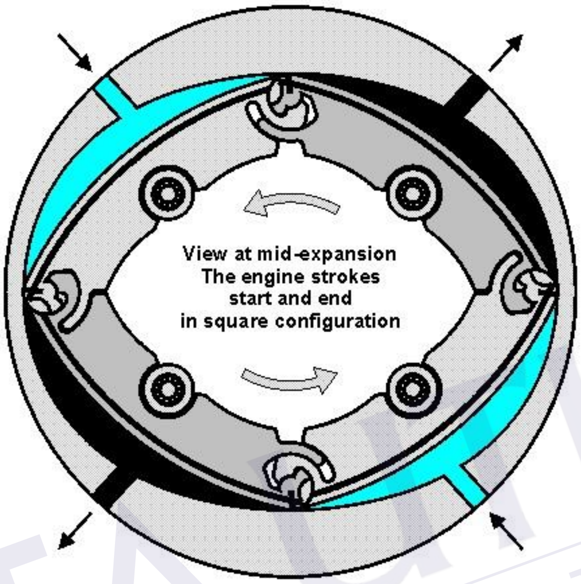

Figure 2.3 Quasiturbine pump

2.3 Components of Quasiturbine

In general , the Quasiturbine has two main parts : rotor and housing .

2.3.1 Housing

The first part of stator casing having an internal contoured housing Wall (oval surface),and it has two ports for inlet and two ports for outlet. The second part are two side cover .

Figure 2.4 Stator casing of Quasiturbine

Figure 2.5 Front cover of Quasiturbine

Figure 2.6 Back cover of Quasiturbine

2.3.2 Rotor

A rotary machine with a deformable rhomb generally comprises a fixed assembly or stator, and a mobile assembly or rotor, having a rhomb shape articulated at its summits and turning around its centre, able to be deformed in particular during its rotation. Each side of the rhomb determines, With the internal profile having a general oval shape of the stator, a variable-volume chamber during the movement of the rotor. The sides of the articulated rhomb are realized by plates, designated pistons, having an external surface of generally curvilinear shape. These pistons are sometimes provided, in their contact Zone With the internal profile of the stator, With tightness segments.

The Quasiturbine rotor has five parts :

2.3.2.1 Rotor segments

Rotor of Quasiturbine compressor has four separated segments that lastly will combine with socket method to permit every part of rotor can move in the oval surface.

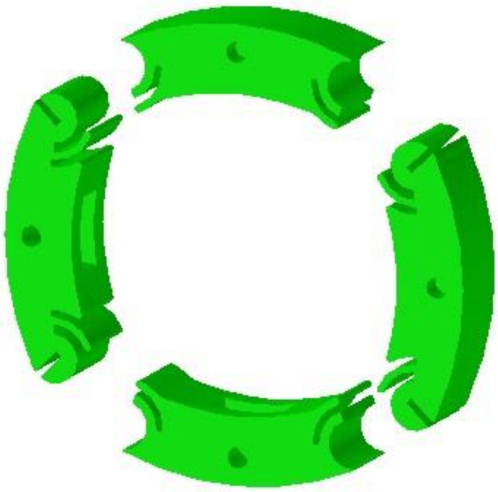

Figure 2.7 Four separated segments

2.3.2.2 Shaft holder

In this Quasiturbine compressor construction the rotor part will attach to the shaft holder. This shaft holder will attach to the shaft and then the shaft will drive by an electric motor. Electric motor will make the shaft work (rotate) and will rotate the shaft holder and rotor. Shaft holder will attach to the shaft by use key method. Part of this shaft holder must be design in detail to make sure that this shaft holder can hold the shaft and bearing.

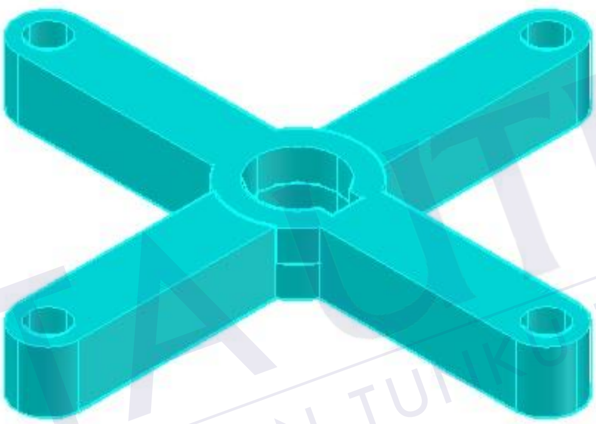

Figure 2.8 Shaft holder

2.3.2.3 Key

The function of this key in this Quasiturbine compressor is to bind between shaft and the shaft holder. Shaft holder that will design is function to transfer the energy from shaft to the rotor. Shaft will receive the energy from the electric motor.

2.3.2.4 Seal

Seal will be the one important component in this Quasiturbine compressor. Seal in this compressor will act as abstraction for four spaces in the housing. During compression and inhale process the seal will act as barricade leakage. Seal will be always touch the compressor’s housing surface assisted by spring. Seal also always touch the surface at angle that near90 degree. Seal will always pull the seal to the housing surface.

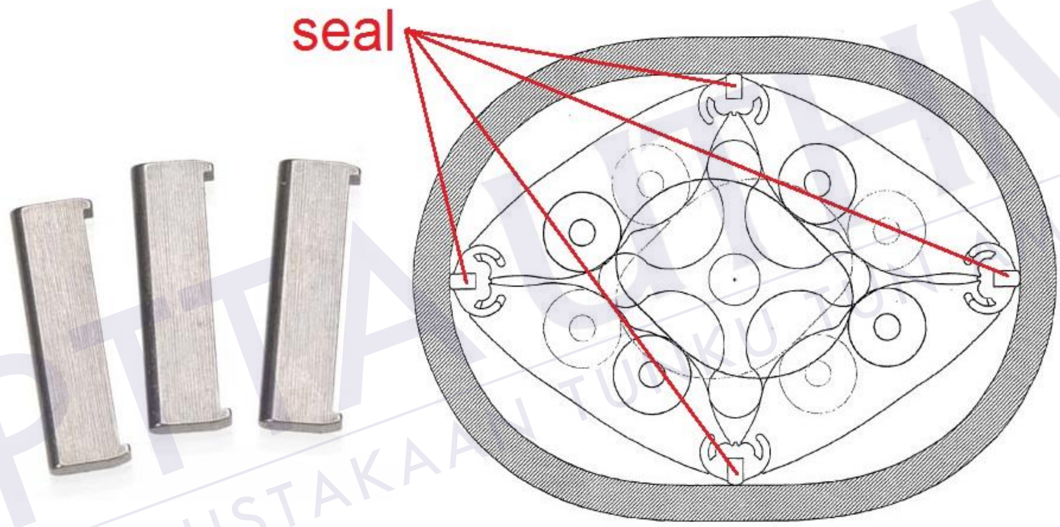

Figure 2.9 Seal of Quasiturbine rotor

2.3.2.5 Spring

Spring is the flexible component that uses to store the mechanical energy. Spring usually is made from metal that was hardened. The small spring normally found in semi hard. While the large spring normally was heat treatment in manufacturing process.

For this Quasiturbine compressor the spring that will use is leaf spring type . Leaf spring was selected because it has characteristic that this compressor need. The part that need this leaf spring serve is at the seal. The leaf spring must be located at the bottom of the seal.The leaf Spring will apply force on the seal to guarantee the seal always contact with oval surface of QT housing to avoid any pressure losses. Spring will be act as rejecter force during rotor move in the housing. Air in the compression and inhale space will leak if the seal not install with spring. Spring have important role at rotor. The role of spring is void air from leak to the near rotor space.

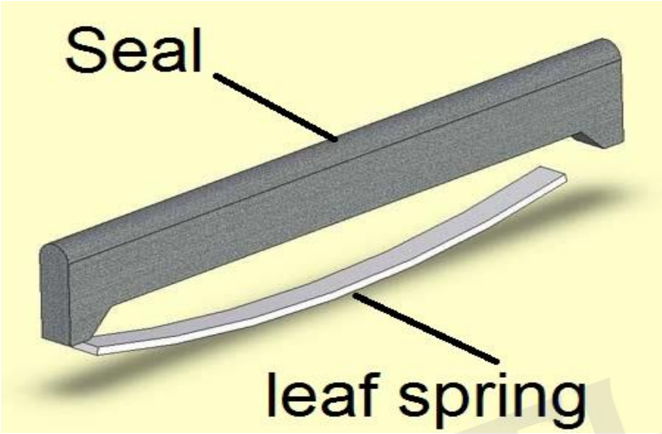

Figure 2.10 leaf spring with the seal

2.4 Types of Quasiturbine rotor

The rotor of Quasiturbine has two main types :

2.4.1 Two-port with carriages

The earliest Quasiturbine design used a three-wheeled carriage to support each vertex of the rotor. The wheels of these four carriages, making twelve wheels in total, ran around the periphery of the engine chamber. A prototype of an internal combustion engine to this design was constructed, and enthusiastically reviewed in European Automotive Design magazine September, 1999. The prototype was turned by an external engine for 40 hours. However, ignition with fuel was never achieved. If it was attempted no results were ever released, and development work on this design was suspended..(CAROL ,2005)

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